JFCC Space Conference Abstract

Human Spaceflight Conjunction Assessment Lessons Learned

In June of 1999, the International Space Station (ISS) attempted a maneuver to avoid a high risk conjunction with a piece of a Russian Soyuz rocket body. The maneuver failed. Although the object missed the ISS and no harm was done to the vehicle or crew, this incident is considered a failure and an example of a breakdown in situational awareness.

In July of 2009, just after the docking of STS-127, the ISS and Space Shuttle mated stack maneuvered to avoid a high risk conjunction from an unknown debris object. This incident is considered a successful use of situational awareness to protect two human spaceflight vehicles and crews.

This paper will compare and contrast these two incidents in human spaceflight conjunction assessment history. Early in the ISS flight program, many lessons were learned regarding conjunction assessment and utilizing conjunction notifications. Through this growing process, there is today a highly successful program of conjunction assessment to protect human spaceflight vehicles and crews. This paper will explain the background behind these two incidents, as well as lessons learned which can be applied to future conjunction assessment activities.

Human Spaceflight Conjunction Assessment

Lessons Learned

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Agenda

- Background
- Object 1844
- Lessons Learned
- Object 84180
- Take-Aways

Background

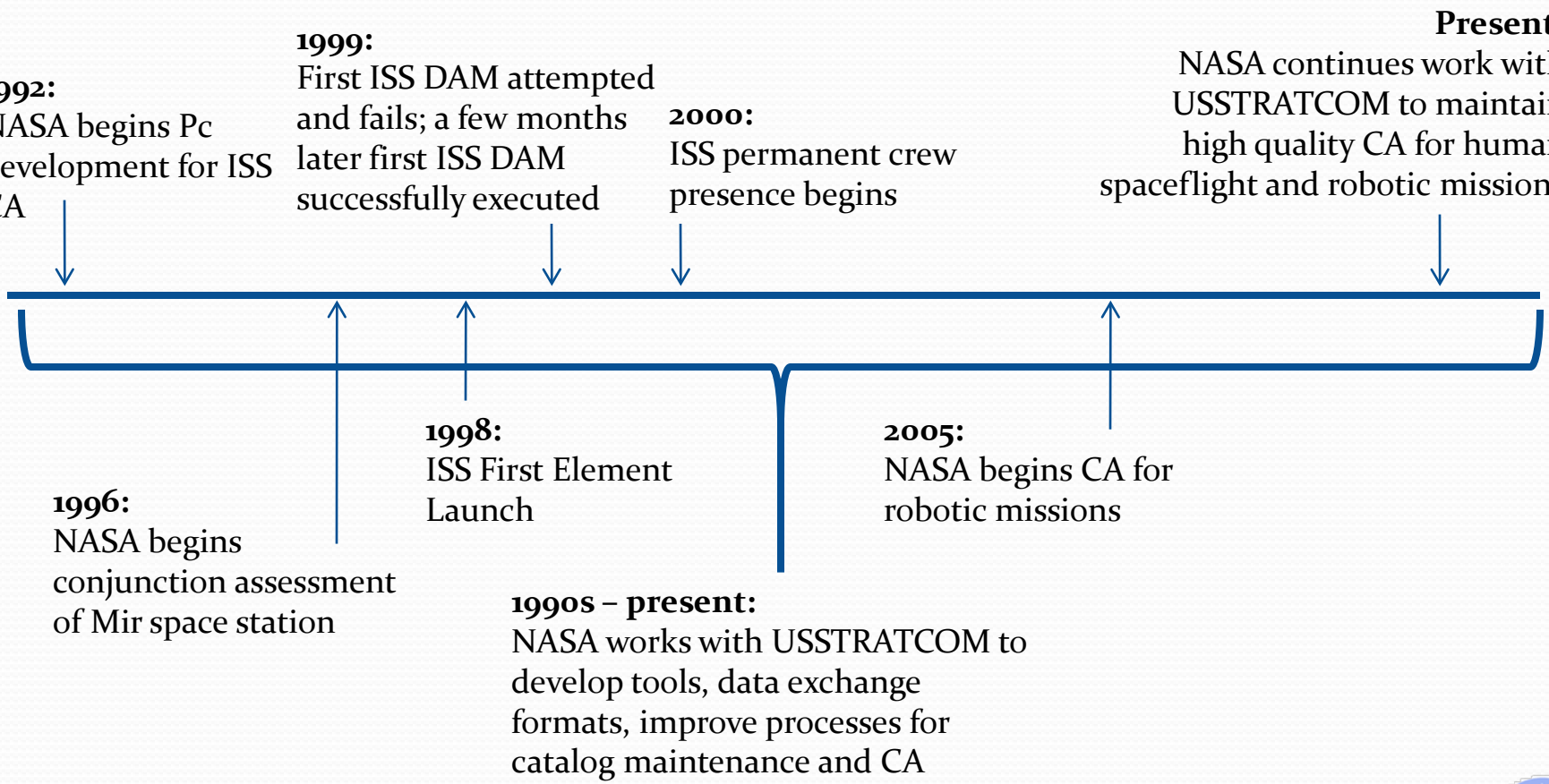
- Since First Element Launch in Nov 1998, the International Space Station (ISS) has had a continuous conjunction assessment team – on-call 24/7/365.
- During this time there have been over 700 conjunction notifications[1].
- Many lessons learned over the 12+ years of ISS operations.
- Examine an example of early conjunction incident (1999).
- Explain some lessons learned from this incident.
- See how these lessons are applied to a more recent conjunction example (2009).

[1] Taken from *NASA Human Spaceflight Conjunction Assessment: Recent Conjunctions of Interest*. Ansley Browns, CSM Workshop, Oct 20, 2010

Acronyms

- DAM – Debris Avoidance Maneuver
- OSA – Orbital Safety Analyst (JSpOC team member responsible for predicting conjunctions for NASA)
- TCA – Time of Closest Approach
- TOPO – Trajectory Operations Officer (Houston Flight Control Team member responsible for conjunction assessment and collision avoidance)

Conjunction Assessment History[2]

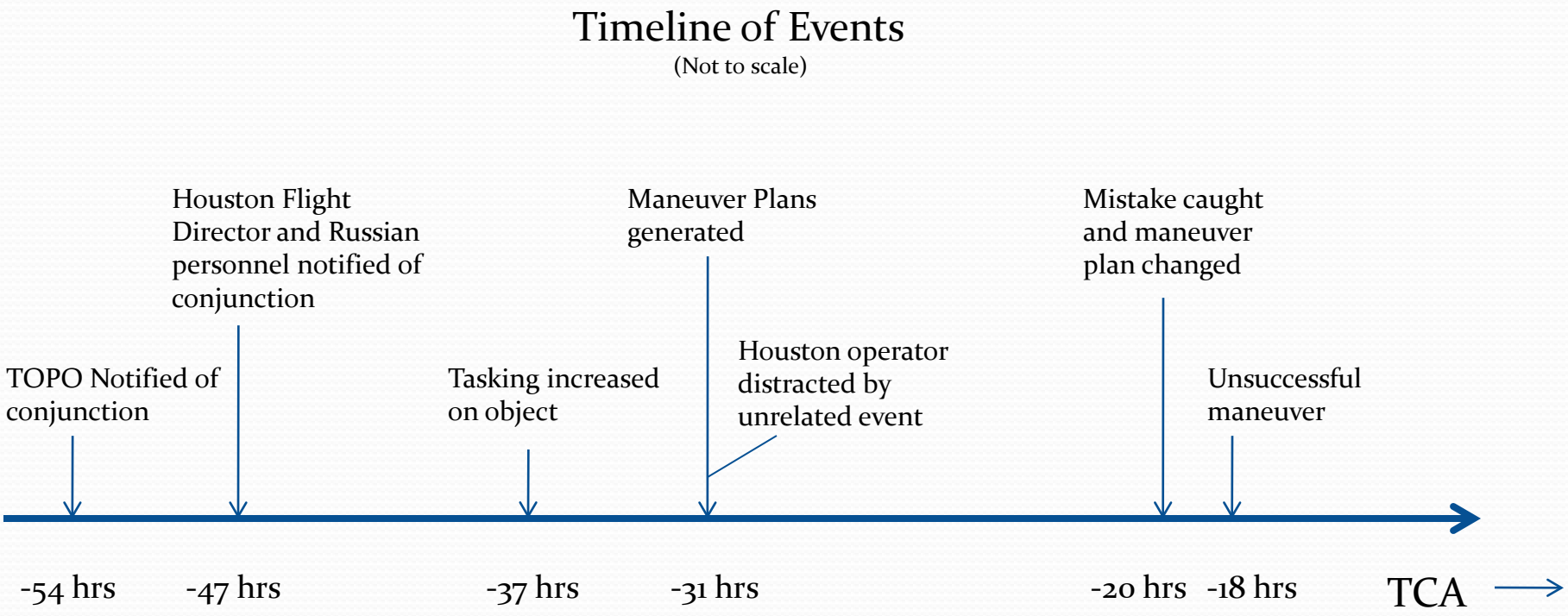


[2] Adapted from *NASA Human Spaceflight Conjunction Assessment: Recent Conjunctions of Interest*. Ansley Browns, CSM Workshop, Oct 20, 2010

Object 1844

- TOPO notified of ISS conjunction with Object 1844 on June 11, 1999.
- The following page presents a timeline of events as they transpired over ~1.5 days following notification of the conjunction.
- Following the timeline are some additional comments on the situation and the outcome.

Object 1844 (con't)



Object 1844 (con't)

- Maneuver execution needed to take place 18 hours or more before TCA due to constraint of flying over Russian ground sites immediately following the burn (this is no longer a constraint).
- Throughout the event there was confusion between TOPO and OSA of what differential correction span to use.
  - Multiple solutions were delivered with no resolution as to what the correct solution should be.
  - At the time, the OSA position was filled with military personnel, making consistent operations difficult due to frequent military rotations.

Object 1844 (con't)

- Distraction resulted in TOPO applying wrong time-tag to a vector sent to OSA for post-burn conjunction screening.
  - This was a manual data entry procedure.
  - Incorrect vector produced false negative screening results. The error was eventually corrected but required a late change in the burn plan.
- Russian command error resulted in loss of attitude control prior to the start of the DAM and hence failure of the burn.
  - Contributing factor to the command error was the late change in the burn plan.
  - Attitude control was regained on the last Russian ground site pass of the day with ~14-28 hours of electrical power remaining.
  - Ironically, post-event reconstruction showed low risk from the conjunction.

Lessons Learned

- Notify people early, get everyone working toward the same goal and have an agreed-to timeline.
- If required, increase tasking early. Waiting reduces the effectiveness.
- When operators are separated by great distances, it is important to understand as much as possible about what the other is doing so as to facilitate questions and discussion.
  - Following this event, the OSA position was moved to contractor personnel, allowing for more retention of experienced operators.
- Automate critical data entry as much as possible. Where automation is not possible, get two sets of eyes on the data.

Object 84180

- Shuttle launched on July 15, 2009 for STS-127 mission.
- TOPO notified of ISS conjunction with Object 84180 on July 16, 2009.
  - First notification ~44 hours prior to TCA – less time than the previous example.
  - Notification came in the middle of Shuttle rendezvous profile (~26 hours prior to docking).
- TCA ~15.5 hours after docking (during crew sleep).
  - Maneuver would need to be performed before sleep.

Object 84180 (con't)

- Within 2 hours, ISS, Shuttle, and International teams are briefed on the situation.
- Immediately following notification, discussions began about when to do a DAM if it became necessary and which vehicle would do it (Shuttle post-docking).
- Several discussions with OSA about increasing tracking and what resources are available.
- Some tracking passes were missed, but the situation was discussed and resolved.
- Post docking perturbations made the conjunction higher risk, so maneuver was executed successfully by Shuttle.

Take-Aways

- Have a plan – don't wait until you are over your head to start swimming.
- Be flexible – every event is unique, so understand when to deviate from the plan.
- Communicate – the easiest path to failure is a breakdown in communication.
- Automate – relying on manual data entry for critical operations should be avoided where possible.
- Don't automate too much – automating data entry is good, automating decision making is not.
- Weigh all the risks – sometimes doing a maneuver is more risky for the vehicle than the conjunction. Don't forget the big picture.

Questions?